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PCT/NZ2005/000038

## CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 4 March 2004 with an application for Letters Patent number 531573 made by DAVID MURRAY MELROSE.

Dated 16 March 2005.



Neville Harris  
Commissioner of Patents, Trade Marks and Designs



Patents Form No. 4

Our Ref: MH504801

Patents Act 1953

PROVISIONAL SPECIFICATION

***CONTAINER LIGHTWEIGHTING AND HEADSPACE DISPLACEMENT  
METHOD FOR REMOVAL OF VACUUM PRESSURE***

I, **DAVID MURRAY MELROSE**, a citizen of New Zealand, of 90 Balmoral Road, Mt Eden, Auckland New Zealand do hereby declare this invention to be described in the following statement:

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## CONTAINER LIGHTWEIGHTING AND HEADSPACE DISPLACEMENT METHOD FOR REMOVAL OF VACUUM PRESSURE

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### Technical Field Of The Invention

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This invention relates generally to a method of light-weighting hot fill containers by utilising a container seal and cap structure that allows for the removal of vacuum pressure. This is achieved by containing and sealing the neck finish of a container during the hot fill process, allowing vacuum to build during liquid cooling, and then displacing the headspace in the upper neck region of the container prior to capping and labelling the container. This invention further relates to hot-filled and pasteurized products packaged in heat-set polyester containers and is particularly useful for packaging oxygen sensitive foods and beverages where a longer shelf life is desirable.

### Background

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So called 'hot fill' containers are well known in prior art, whereby manufacturers supply PET containers for various liquids which are filled into the containers and the liquid product is at an elevated temperature, typically at or around 85 degrees C (185 degrees F).

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The container is manufactured to withstand the thermal shock of holding a heated liquid, resulting in a 'heat-set' plastic container. This thermal shock is a result of either introducing the liquid hot at filling, or heating the liquid after it is introduced into the container.

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Once the liquid cools down in a capped container, however, the volume of the liquid in the container reduces, creating a vacuum within the container. This liquid shrinkage results in vacuum pressures that pull inwardly on the side and end walls of the container. This in turn leads to deformation in the walls of plastic bottles if they are not constructed rigidly enough to resist such force.

Typically, vacuum pressures have been accommodated by the use of vacuum panels, which distort inwardly under vacuum pressure. Prior art reveals many vertically oriented vacuum panels that allow containers to withstand the rigors of a hot fill procedure. Such vertically oriented vacuum panels generally lie parallel to the longitudinal axis of a container and flex inwardly under vacuum pressure toward this longitudinal axis.

In addition to the vertically oriented vacuum panels, many prior art containers also have flexible base regions to provide additional vacuum compensation. Many prior art containers designed for hot-filling have various modifications to their end-walls, or base regions to allow for as much inward flexure as possible to accommodate at least some of the vacuum pressure generated within the container.

Even with such substantial displacement of vacuum panels, however, the container requires further strengthening to prevent distortion under the vacuum force.

The liquid shrinkage derived from liquid cooling, causes a build up of vacuum pressure. Vacuum panels deflect toward this negative pressure, to a degree lessening the vacuum force, by effectively creating a smaller container to better accommodate the smaller volume of contents. However, this smaller shape is held in place by the generating vacuum force. The more difficult the structure is to deflect inwardly, the more vacuum force will be generated. In prior art, a substantial amount of vacuum is still present in the container and this tends to distort the overall shape unless a large, annular strengthening ring is provided in horizontal, or transverse, orientation at least a 1/3 of the distance from an end to the container.

The present invention relates to hot-fill containers and may be used in conjunction with the hot fill containers described in our international applications WO 02/18213 (PCT specification), and PCT/NZ03/00220 (PCT specification) which specifications are incorporated herein in entirety where appropriate.

The PCT specifications background the design of hot-fill containers and the problems with such designs that were overcome or at least ameliorated.

A problem exists when locating such a transversely oriented panel in the container side-wall, end-wall or base region, whereby once vacuum is removed completely from the container after the liquid cools down and the panel is inverted. While the container exits

from the filling line with ambient pressure as opposed to negative pressure found in prior art, the container is labelled and often refrigerated at point of sale.

5 This refrigeration provides further product contraction and in containers with very little sidewall structure, so-called 'glass look-a-likes', there may be some panelling occur on the containers that is unsightly. To overcome this, an attempt is made to provide the base transverse panel with more extraction potential than is required, so that it may be forced into inversion against the force of the small headspace present during filling. This creates a small positive pressure at fill time, and this positive pressure provides some relief to the situation. As further cool down occurs, for example during refrigeration, the positive pressure may drop and hopefully provide for an ambient pressure at refrigerated temperatures, and so avoid panelling in the container.

10 This situation is very hard to engineer successfully, however, as it depends on utilising a larger headspace in order to compress at base inversion time, and it is less desirable to introduce a larger headspace to the container than is necessary in order to retain product quality.

15 While it is desirable to have the liquid level in the container drop, to avoid spill when opened by the consumer, it has been found that providing too much positive pressure potential within the base may cause some product spill when the container is opened, particularly if at ambient temperatures.

20 A further problem exists with hot fill containers, whereby the neck finish is subjected to direct heat from the liquid after the container is filled. The containers are often turned upside down after being capped and the heat transferred to the inside of the neck finish, prior to the liquid being cooled down, will distort the plastic within the neck finish.

25 For this reason the neck finish region is often manufactured thicker, or heavier in material in order to cope with the heat during this phase. This adds to the cost of the container.

30 In most filling operations, containers are generally filled to a level just below the container's highest level, at the top of the neck finish.

35 Maintaining as small a container headspace as possible is desirable in order to provide a tolerance for subtle differences in product density or container capacity, to minimize waste

from spillage and overflow of liquids on a high-speed package filling line, and to reduce in container contraction from cooling contents after hot fill.

5       Headspace contains gases that in time can damage some products or place extra demands on container structural integrity. Examples include products sensitive to oxygen and products filled and sealed at elevated temperatures.

      Filling and sealing a rigid container at elevated temperatures can create significant vacuum forces when excessive headspace gas is also present.

10       Accordingly, less headspace gas is desirable with containers filled at elevated temperatures, to reduce vacuum forces acting on the container that could compromise structural integrity, induce container stresses, or significantly distort container shape. This is also true during pasteurization and retort processes, which involve filling the container  
15       first, sealing, and then subjecting the package to elevated temperatures for a sustained period.

      Those skilled in the art are aware of several container manufacturing heat-set processes for improving package heat-resistant performance. In the case of the  
20       polyester, polyethylene terephthalate, for example, the heat-setting process generally involves relieving stresses created in the container during its manufacture and to improve crystalline structure.

      Typically, a polyethylene terephthalate container intended for a cold-fill carbonated  
25       beverage has higher internal stresses and less crystalline molecular structure than a container intended for a hot-fill, pasteurized, or retort product application. However, even with containers such as described in international applications WO 02/18213 (PCT specification), and PCT/NZ03/00220 (PCT specification) , where there is little residual vacuum pressure, the neck finish of the container is still required to be very thick in order  
30       to withstand the temperature of fill.

### **Objects Of The Invention**

35       In view of the above, it is an object of one preferred embodiment of the present invention to provide a headspace displacement method that can provide for removal of vacuum pressure such that there is substantially no remaining force within the container.

It is a further object of one preferred embodiment of the present invention to provide a headspace displacement method whereby a heat resistant seal is applied to the neck finish that is displaceable into the container.

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It is a further object of one preferred embodiment of the present invention to provide a headspace displacement method whereby a heat resistant seal is applied to the neck finish that is displaceable into the container, and is held in place by a temporary neck finish enclosing device that protects the neck finish from the adverse effects of temperature while the filled liquid is hot.

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It is a further object of one preferred embodiment of the present invention to provide a headspace displacement method whereby a heat resistant seal is applied to the neck finish that is forcibly displaceable into the container, such that a strong positive pressure may be induced into the container.

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It is a further object of one preferred embodiment of the present invention to provide a headspace displacement method whereby a heat resistant seal is applied to the neck finish that is retractable into the container under the effect of vacuum pressure alone.

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It is a further object of one preferred embodiment of the present invention to provide a headspace displacement method whereby a heat resistant seal is applied to the neck finish that provides a protected pocket within the capped neck finish for additional ingredients or promotional items may be situated.

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A further and alternative object of the present invention in all its embodiments, all the objects to be read disjunctively, is to at least provide the public with a useful choice.

### **Summary Of The Invention**

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According to one aspect of the present invention there is provided a container having a longitudinal axis, an upper portion having an opening into said container, said upper portion having a neck finish that is suitable for having a cap applied.



Preferably the introduction of a hot liquid to the container an expandable seal is applied to the neck finish of the container. Preferably the liquid is filled to as high a point as possible, so that upon sealing there is a minimal headspace remaining in the container.

5 A temporary cap system may be applied to cover the seal. The temporary cap acts as a neck finish enclosing device that serves to compress the expandable seal into the container, thereby mildly pressurising the contents, and more importantly encasing the neck finish. Such enclosure of the neck finish provides protection from the adverse effects of the heated liquid when the bottle is turned upside down. By bracing the neck  
10 finish not only is the heat kept from direct contact with the neck finish, but any transferred heat is prevented from distorting the neck finish for a period of time until the beverage has cooled.

15 Further, the enclosing device temporarily covers the seal to prevent cooling water being sprayed into the inside pocket during the cycle of water cooling.

Following cool down, the enclosing device may be removed and a permanent cap applied to the container.

20 According to one aspect of the present invention the expandable seal may be drawn in to full extension simply by the vacuum pressure alone once the temporary cap has been removed. Once equilibrium has been established, and this is virtually immediate, the new cap may simply be applied.

25 According to a further aspect of the present invention the permanent cap may also be downwardly forcible, such that the headspace now separated from the liquid, being above the seal, may be compressed to provide for an increased pressure within the container.

30 According to a further aspect of the present invention, a simple permanent cap may be applied, such that the headspace now separated from the liquid, being above the seal, may be compressed by inverting a transverse base panel against the capped container at this time.

35 According to one aspect of the present invention, by providing a temporary enclosing device to the neck finish, a substantial amount of weight may be removed from the part, without risk of distortion from the heat applied during the process.

According to a further aspect of the present invention, the complete removal of vacuum pressure by displacing the headspace after the liquid has contracted, results in being able to remove a substantial amount of weight from the sidewalls due to the removal of mechanically distorting forces.

Further aspects of the invention which should be considered in all its novel aspects will become apparent from the following description.

### **Brief Description of Drawings**

**Figure 1a:** shows a cross-sectional view of a hot-fill container according to one possible embodiment of the invention in its open condition and filled to just below the top of the neck finish;

**Figure 1b:** shows the typical fluid level after liquid contraction from cooling in the container of Figure 1a;

**Figure 2a:** shows the container of Figure 1a immediately post-fill, and with an expandable seal applied to the top of the neck finish to secure the beverage and small headspace under the seal;

**Figure 2b:** shows the container of Figure 2a with a temporary cap applied during the cool down process to protect the seal from water spray damage;

**Figure 2c:** shows the container of Figure 2b post cool down and liquid contraction with the temporary cap removed.

**Figure 2d:** shows the container of 2c with a permanent cap applied;

**Figure 3a-b:** shows a container with a mechanically compressible cap applied to seal the beverage;

**Figure 3c-d:** shows the container of Figure 3a-b with the compressible cap in the compressed state to displace the headspace vacuum and

provide positive pressure to the inside of the container post cooling;

**Figure 4a:** shows the container of Figure 2a

**Figure 4b:** shows the container of Figure 4a with a temporary enclosing cap applied to expand the seal downwardly, increase the pressure within the container, and enclose the neck finish and protect it from heat

**Figure 4c:** shows the container of Figure 4b post cool down with the temporary enclosing cap removed and post expansion of the seal

**Figures 4d:** show the container of Figure 4c with a permanent cap applied.

**Figures 5a-b:** shows an enlarged view of an example expandable seal in the collapsed form and in the expanded form

**Figure 6a-b:** shows an enlarged view of an example compressive cap in the uncompressed and compressed states;

**Figure 7a-d:** shows an example of locating an ingredient within the pocket contained between the expandable seal and cap, and then removing the cap, removing the seal and placing the ingredient into the beverage;

### **Detailed Description Of Preferred Embodiments**

The following description of preferred embodiments is merely exemplary in nature, and is in no way intended to limit the invention or its application or uses.

As discussed above, to accommodate vacuum forces during cooling of the contents within a heat set container, containers have typically been provided with a series of vacuum panels around their sidewalls and an optimized base portion. The vacuum panels deform inwardly, and the base deforms upwardly, under the influence of the vacuum forces. This

prevents unwanted distortion elsewhere in the container. However, the container is still subjected to internal vacuum force. The panels and base merely provide a suitably resistant structure against that force. The more resistant the structure the more vacuum force will be present. Additionally, end users can feel the vacuum panels when holding the containers.

Typically at a bottling plant the containers will be filled with a hot liquid and then capped before being subjected to a cold water spray resulting in the formation of a vacuum within the container which the container structure needs to be able to cope with. The present invention relates to hot-fill containers and a method that provides for the substantial removal or substantial negation of vacuum pressure. This allows much greater design freedom and light weighting opportunities as there is no longer any requirement for the structure to be resistant to vacuum forces which would otherwise mechanically distort the container.

According to one aspect of the present invention a container is provided having a longitudinal axis, an upper portion having a neck finish that is suitable for having a cap applied.

As seen in Figures 1a and b, when hot liquid is introduced to a container, if left uncapped the liquid would contract to some degree. Should a cap be applied immediately post fill, which is a necessity, then a vacuum builds up under the cap and is only released when the cap is removed.

Referring to Figures 2a and b, in one preferred form the current invention provides for an expandable seal to be applied to the neck finish of the container following the introduction of the hot liquid to the container. Preferably the liquid is filled to as high a point as possible, so that upon sealing there is a minimal headspace remaining in the container. The seal provides integrity such that outside air may no longer interact with the liquid.

A temporary cap system is applied to cover the expandable seal. The temporary cap provides protection from the water spray typically used to cool the container down prior to application of a label.

As the product cools, a vacuum will build up within the container under the temporary cap and distort the container to a degree.

Once the product is cooled the temporary cap is removed as shown in Figure 2c. Immediately the vacuum pressure within the container draws the expandable seal downwards and thereby the pressure within the container is equalised. Distortion is removed from the container and a permanent cap is then applied, as shown in Figure 2d, and a label applied to the container.

According to another aspect of the present invention, the sealing cap could be achieved by application of a mechanical cap that has an out position and an in position. Referring to Figures 3a and b, a compressive cap is applied to the container immediately post filling with a hot beverage. This seals the beverage. Once cooled, a vacuum builds up and the container distorts. Once cooled down, the inside of the cap is screwed down to the in position, thereby displacing the headspace vacuum and distortion, see Figures 3c-d. Mechanical compression can therefore achieve a positive pressure to enable the container to be refrigerated without panelling.

Referring now to Figures 4a and b, according to a further aspect of the present invention the temporary cap may act as a neck finish enclosing device that serves to compress the expandable seal into the container, thereby mildly pressurising the contents, and more importantly encasing the neck finish. Such enclosure of the neck finish provides protection from the adverse effects of the heated liquid when the bottle is turned upside down. By bracing the neck finish not only is the heat kept from direct contact with the neck finish, but any transferred heat is prevented from distorting the neck finish for a period of time until the beverage has cooled.

Further, the enclosing device temporarily covers the seal to prevent cooling water being sprayed into the inside pocket during the cycle of water cooling.

Referring to Figure 4c, following cool down, the enclosing device is removed allowing the expandable seal to be drawn in to position of pressure equilibrium, and a permanent cap may then be applied to the container, as shown in Figure 4d.

According to one aspect of the present invention the expandable seal may be drawn in to full extension simply by the vacuum pressure alone once the temporary cap has been removed. Once equilibrium has been established, and this is virtually immediate, the new cap may simply be applied.

According to a further aspect of the present invention the permanent cap may also be downwardly forcible, such that the headspace now separated from the liquid, being above the seal, may be compressed to provide for an increased pressure within the container.

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According to a further aspect of the present invention, a simple permanent cap may be applied, such that the headspace now separated from the liquid, being above the seal, may be compressed by inverting a transverse base panel against the capped container at this time.

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According to one aspect of the present invention, by providing a temporary enclosing device to the neck finish, a substantial amount of weight may be removed from the part, without risk of distortion from the heat applied during the process.

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According to a further aspect of the present invention, the complete removal of vacuum pressure by displacing the headspace after the liquid has contracted, results in being able to remove a substantial amount of weight from the sidewalls due to the removal of mechanically distorting forces.

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Where in the foregoing description, reference has been made to specific components or integers of the invention having known equivalents then such equivalents are herein incorporated as if individually set forth.

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Although this invention has been described by way of example and with reference to possible embodiments thereof, it is to be understood that modifications or improvements may be made thereto without departing from the scope of the invention as defined in the appended claims.

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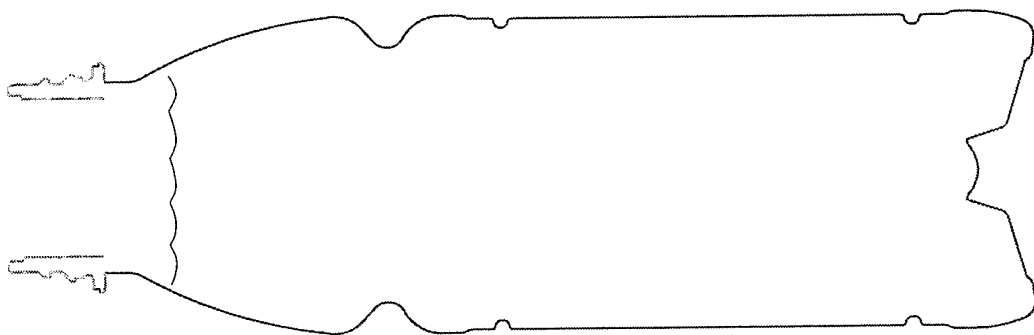


FIGURE 1b

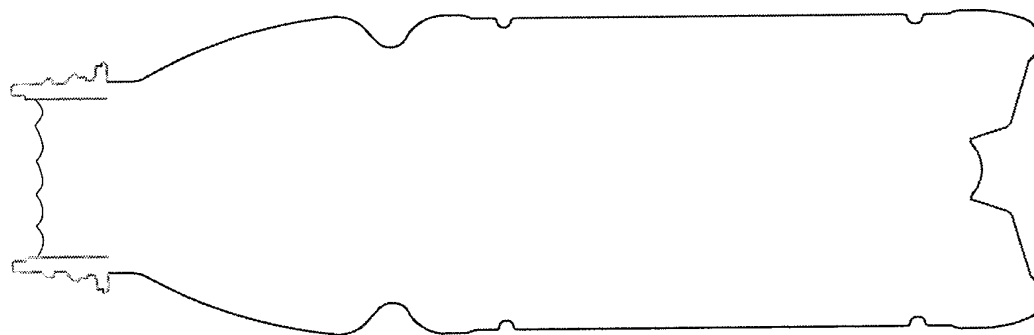
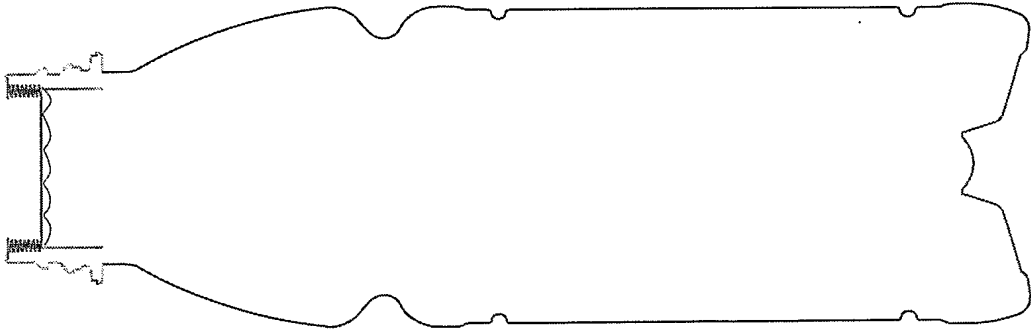
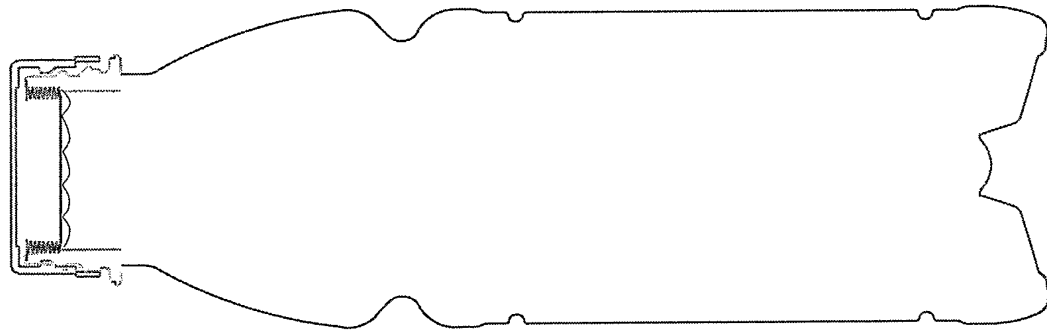


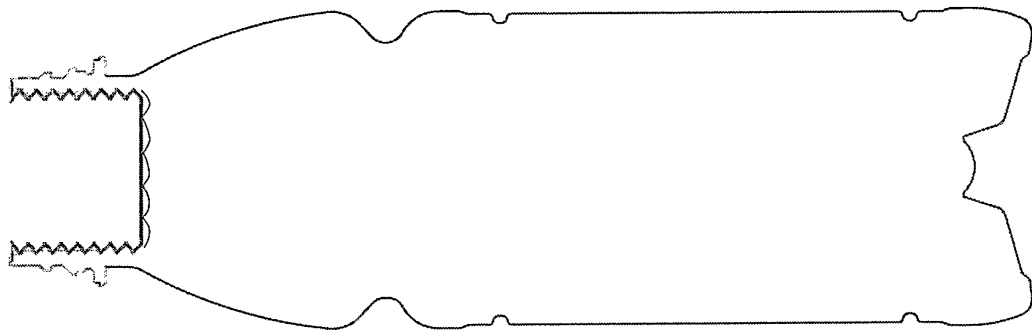
FIGURE 1a



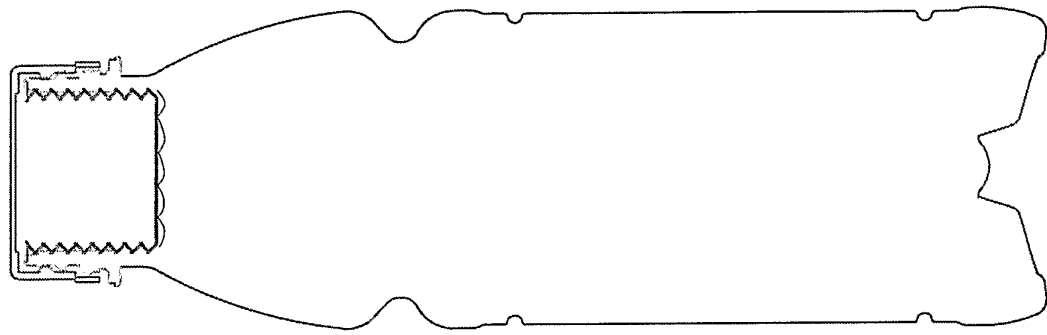
**FIGURE 2a**



**FIGURE 2b**



**FIGURE 2c**



**FIGURE 2d**



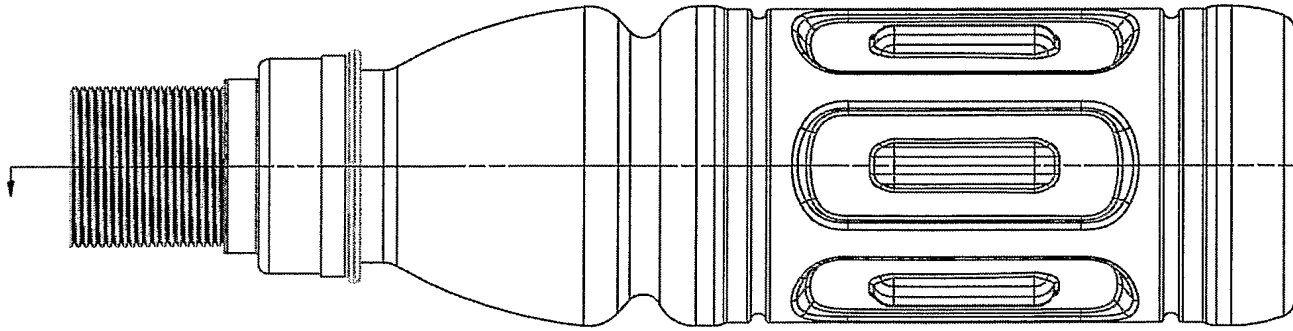


FIGURE 3a

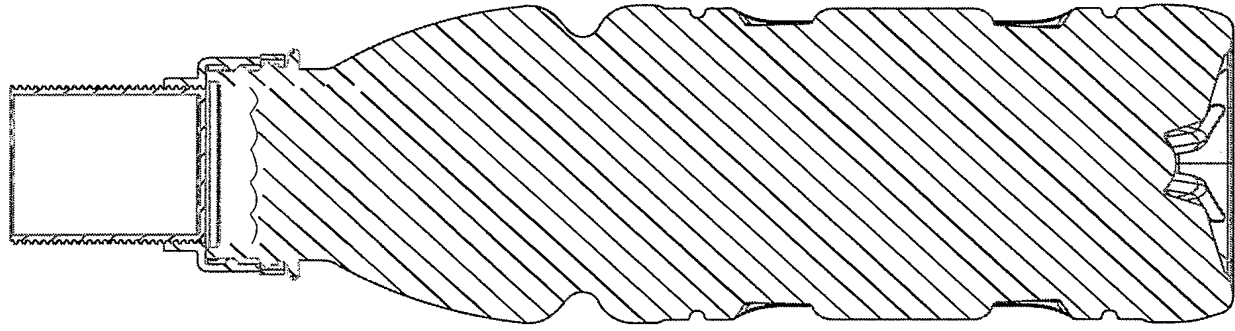


FIGURE 3b

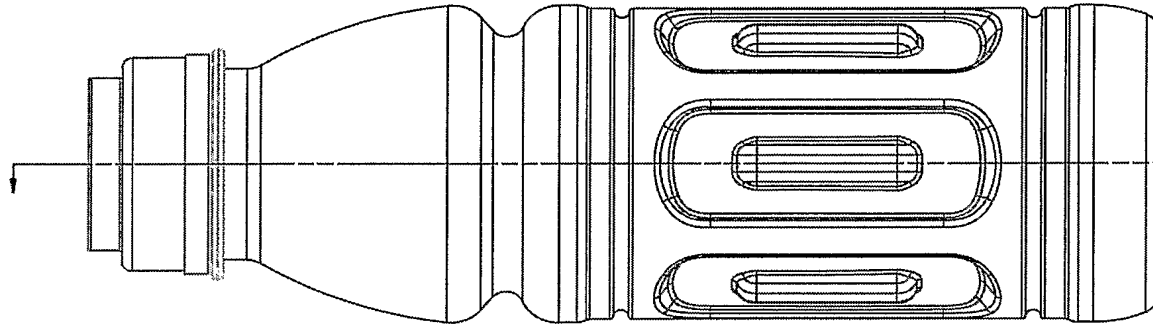


FIGURE 3c

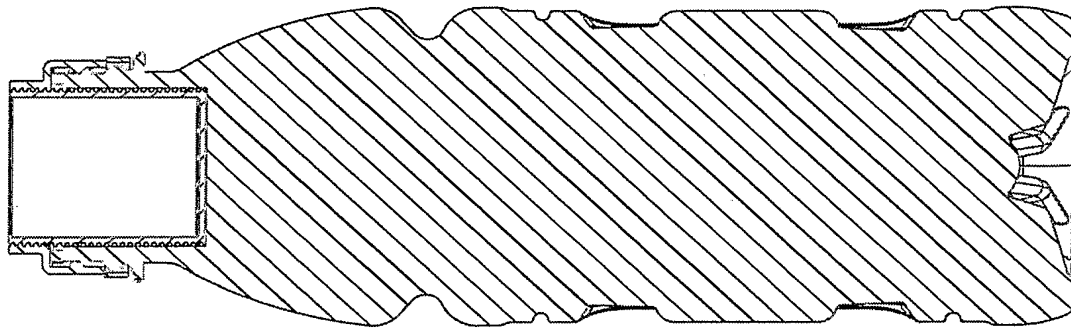
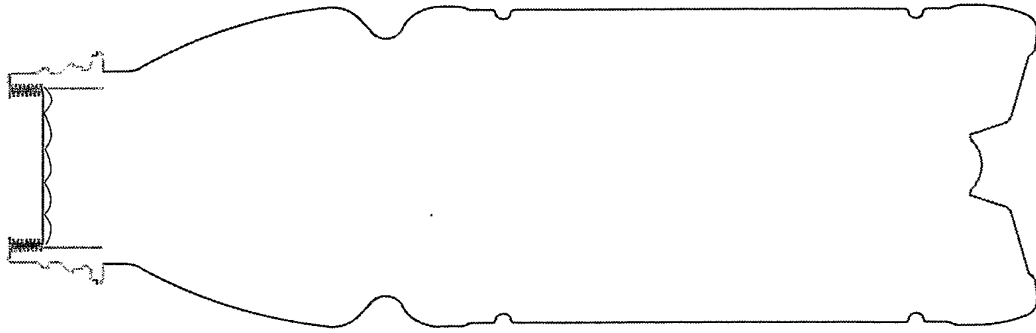
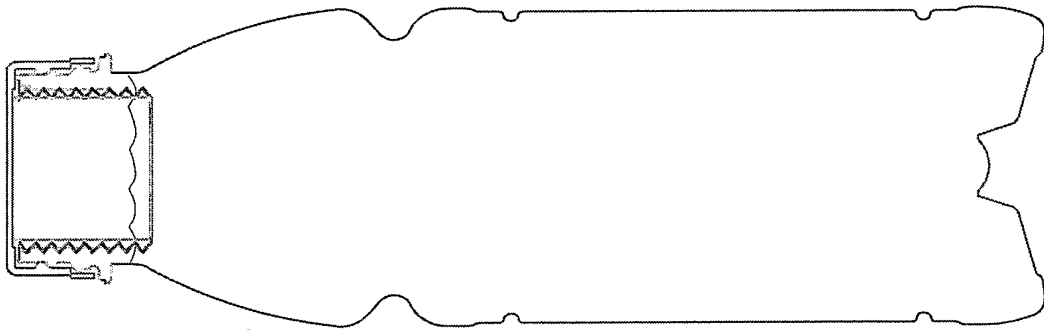


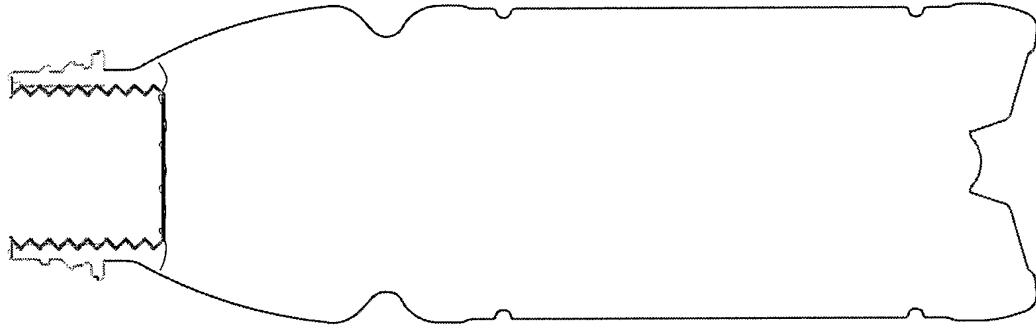
FIGURE 3d



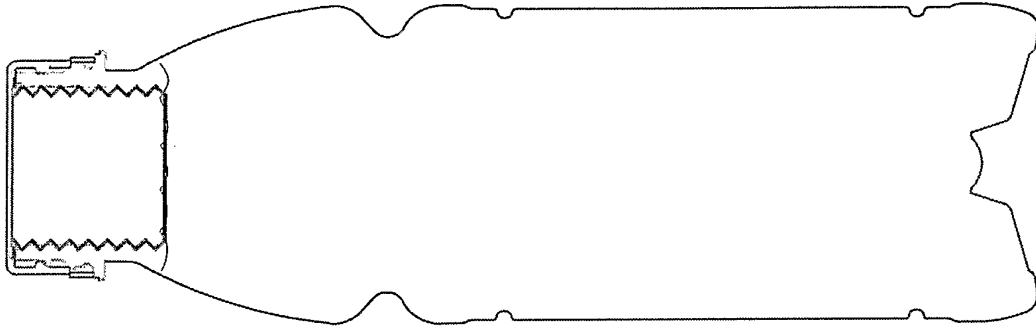
**FIGURE 4a**



**FIGURE 4b**



**FIGURE 4c**



**FIGURE 4d**



FIGURE 5a

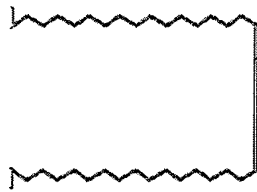


FIGURE 5b

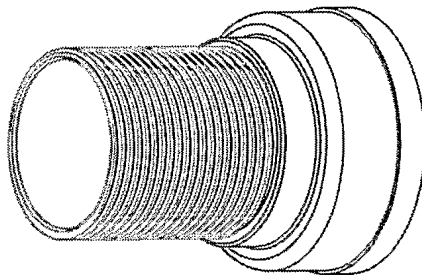


FIGURE 6a

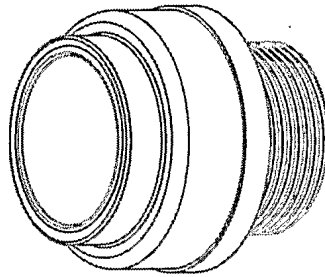


FIGURE 6b

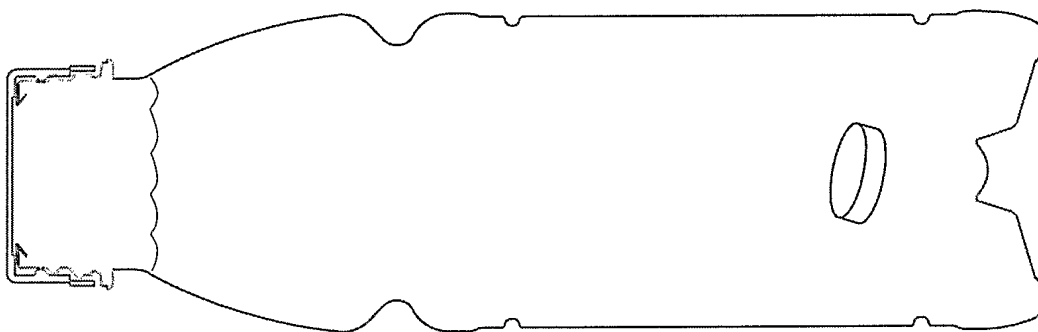


FIGURE 7d

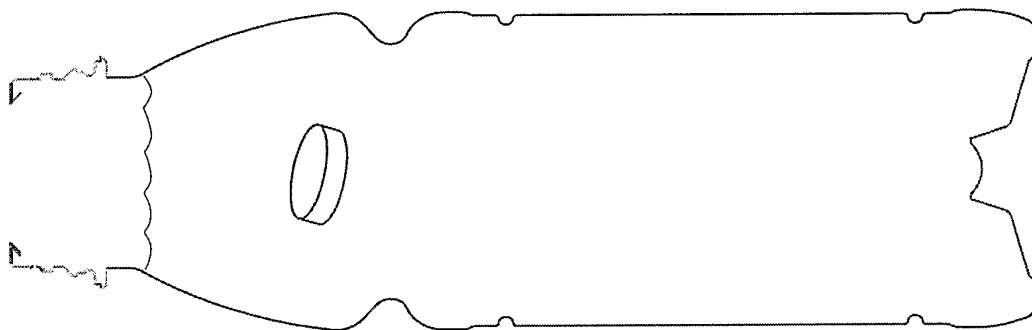


FIGURE 7c

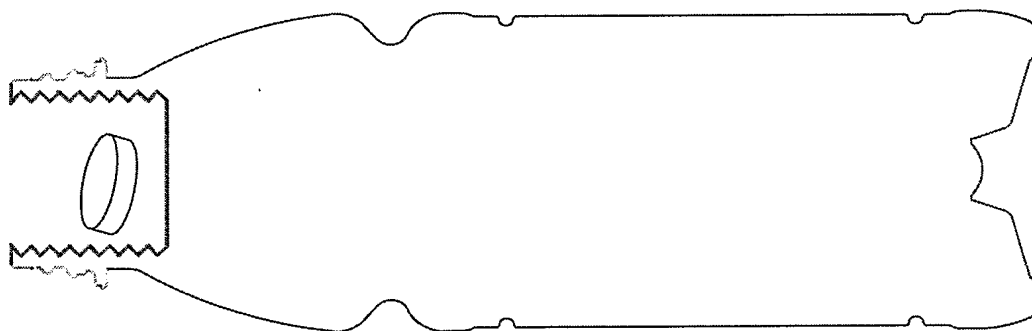


FIGURE 7b

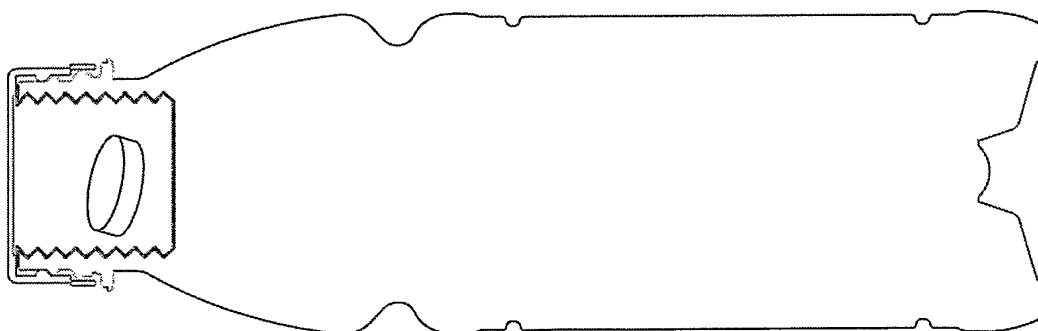


FIGURE 7a